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Handling of Thermal Receipts as a Source of Exposure to Bisphenol A

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Human exposure to bisphenol A (BPA) has been associated with adverse health outcomes, including reproductive function in adults[1] and neurodevelopment in children exposed perinatally.[2] Exposure to BPA is primarily through dietary ingestion, including consumption of canned foods.[3] A less-studied source of exposure is thermal receipt paper,[4] handled daily by many people at supermarkets, ATM machines, gas stations, and other settings. We hypothesized that handling of thermal receipts significantly increases BPA exposure, but use of gloves during handling minimizes exposure.

Methods

In 2010–2011, after obtaining written informed consent, we recruited Harvard School of Public Health students and staff (aged >18 years, nonpregnant) via informational fliers and e-mail. No sample size calculation was performed for this pilot study, which was approved by the Harvard University institutional review board.

We used a simulation cross-over study design. At the first simulation, participants printed and handled receipts continuously for 2 hours without gloves. After a washout period of at least 1 week, a second simulation was conducted in which participants repeated handling of

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Author Contributions: Dr Ehrlich had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Ehrlich, Smith, Hauser.
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Drafting of the manuscript: Ehrlich, Humblet, Hauser.
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receipts wearing nitrile gloves. The option to participate in the second simulation or to provide sequential urine samples following the first simulation was offered to all participants at study entry.

All participants provided a spot urine sample, collected in a sterile BPA-free polypropylene specimen cup, immediately before handling of receipts and 4 hours later. Volunteers provided additional sequential urine samples at 8, 12, and 24 hours after handling of receipts without gloves. Urinary-specific gravity was measured using a handheld refractometer. Urine was stored in polypropylene cryogenic vials at or below −20°C until analysis. Total (free plus conjugated species) urinary BPA concentration was measured at the US Centers for Disease Control and Prevention using published methods.[1] Concentrations of BPA were adjusted for specific gravity to account for urine dilution.

Using SAS version 9.3 (SAS Institute Inc), mixed regression models were used to examine associations between log-transformed specific gravity–adjusted urinary BPA concentrations for prehandling and posthandling samples and across time points for those who provided sequential urine samples. Statistical significance was set at a $P \leq .05$ (2-sided test).

Results

Twenty-four volunteers (mean age [SD], 35 [12] years) provided at least 2 urine samples for the simulation without gloves; 12 volunteers provided additional sequential samples and 12 also completed the simulation with gloves (Table). We excluded 1 participant for reporting consumption of 4 cans of beverage prior to the simulation (baseline urinary BPA concentration of 49.3 μg/L vs <2 μg/L for the remaining participants, decreasing to 12.0 μg/L postsimulation).

We detected BPA in 83% (n = 20) of samples at baseline and in 100% of samples after handling receipts without gloves. The geometric mean urinary BPA concentration was 1.8 μg/L (95% CI, 1.3–2.4 μg/L) before simulation and 5.8 μg/L (95% CI, 4.0–8.4 μg/L) postsimulation ($P = .005$ for interaction between presimulation and postsimulation BPA and glove status). The geometric mean BPA urinary concentrations from 12 participants who provided sequential samples following receipt handling without gloves were 2.1 μg/L (95% CI, 1.4–3.3 μg/L) at baseline, 6.0 μg/L (95% CI, 3.4–10.7 μg/L) at 4 hours, 11.1 μg/L (95% CI, 5.5–22.8 μg/L) at 8 hours, 10.5 μg/L (95%CI, 4.9–22.6 μg/L) at 12 hours, and 4.7 μg/L (95%CI, 2.4–9.1 μg/L) at 24 hours. Each measure was significantly different from baseline ($P < .001$ for 4-hour, 8-hour, and 12-hour urine samples and $P = .04$ for 24-hour samples). We observed no significant increase in urinary BPA after handling receipts with gloves (Figure).

Discussion

In this pilot study, we observed an increase in urinary BPA concentrations after continuously handling receipts for 2 hours without gloves, but no significant increase when using gloves. The peak level (5.8 μg/L) was lower than that observed after canned soup consumption (20.8μg/L).[3] The clinical implications of the height of the peak level and the

chronicity of exposure are unknown, but may be particularly relevant to occupationally exposed populations such as cashiers,[5] who handle receipts 40 or more hours per week.

Limitations include the small volunteer sample and loss of participants in the second simulation. However, urinary BPA concentrations at baseline were similar in the full and smaller groups and similar to the US population (1.83 μg/L).[6] A larger study is needed to confirm our findings and evaluate the clinical implications.

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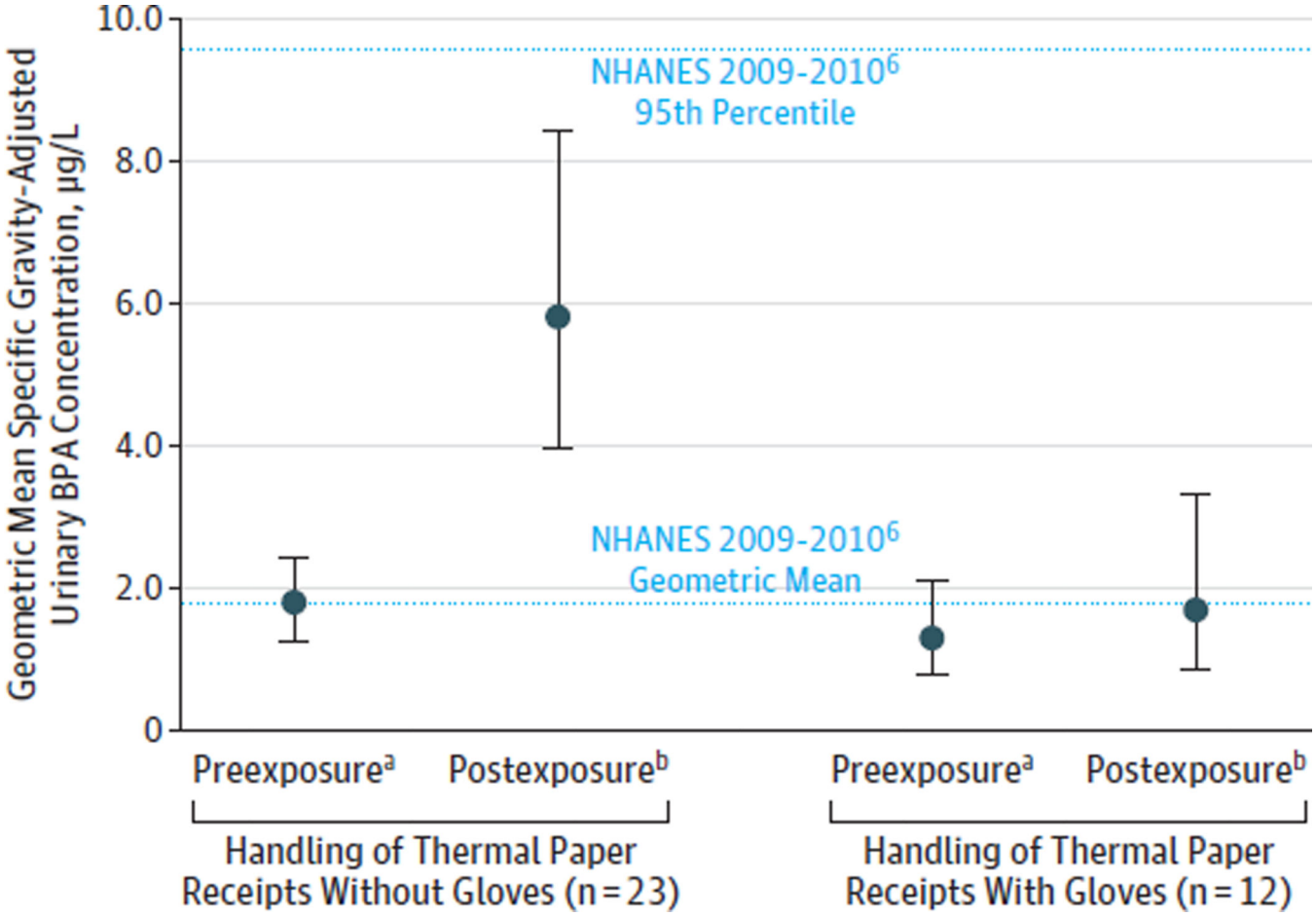

Figure. Geometric Mean–Specific Gravity-Adjusted Urinary Bisphenol A (BPA) Concentration

Error bars indicate 95%confidence intervals. NHANES indicates National Health and Nutrition Examination Survey.

[a] Adjusted BPA at 0 hours (baseline).

[b] Adjusted BPA at 4 hours (handled receipts for 2 hours).

Table

Demographic Characteristics of 24 Study Participants

	Simulation Without Gloves (n = 24)[a]	Sequential Urine Samples (n = 12)	Simulation With Gloves (n = 12)
Sex, No. (%)			
Female[a]	19 (79)	8 (67)	9 (75)
Male	5 (21)	4 (33)	3 (25)
Age, mean (SD) [range], y	35 (12) [26–71]	33 (12) [26–71]	34 (13) [26–71]
Ethnicity, No. (%)			
White[a]	15 (63)	9 (75)	7 (58)
Black	5 (21)	2 (17)	2 (17)
Asian	4 (17)	1 (1)	3 (25)
Specific gravity–adjusted bisphenol A at baseline, geometric mean (95% CI), μg/L	1.8 (1.3–2.4)	2.1 (1.4–3.3)	1.3 (0.8–2.1)[b]

[a] One participant was excluded from final analyses because of high background exposure to bisphenol A from consuming 4 cans of cold beverage (had urinary-specific gravity–adjusted bisphenol A concentration 25-fold higher than the National Health and Nutrition Examination Survey 2009-2010 geometric mean of 1.83 μg/L[6]).

[b] There was no statistically significant baseline difference for simulations with gloves vs without gloves ($P = .76$).